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GRANITES OF NORTH CAROLINA.[1]

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[1] Published by permission of the state geologist of North Carolina.

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INTRODUCTION.

The following paper is based on a study of the granites and gneisses of North Carolina during the past field season, while I was engaged on the State Geological Survey in a field study of these rocks. The economic report treating of the granites has been prepared and will form a part of a general report on the building-stones of North Carolina to be published by the State Survey. A general summary setting forth the more important points in the petrography and structure of these rocks is offered in the present paper as a separate contribution.

DISTRIBUTION OF THE GRANITES.

North Carolina is divisible naturally into three principal physiographic provinces, which, named in order from east to west, are: the Coastal Plain, the Piedmont Plateau, and the Appalachian Mountains. These form a part of the continuation of the same provinces to the north and south of North Carolina; and they observe approximate parallelism with each other and with the general trend of the coast line of the southeastern Atlantic states. The granites of North Carolina are distributed over parts of each of these three provinces; the areas being fewer and smaller over the Coastal Plain region, and more numerous and larger over the Piedmont Plateau region. Gran-

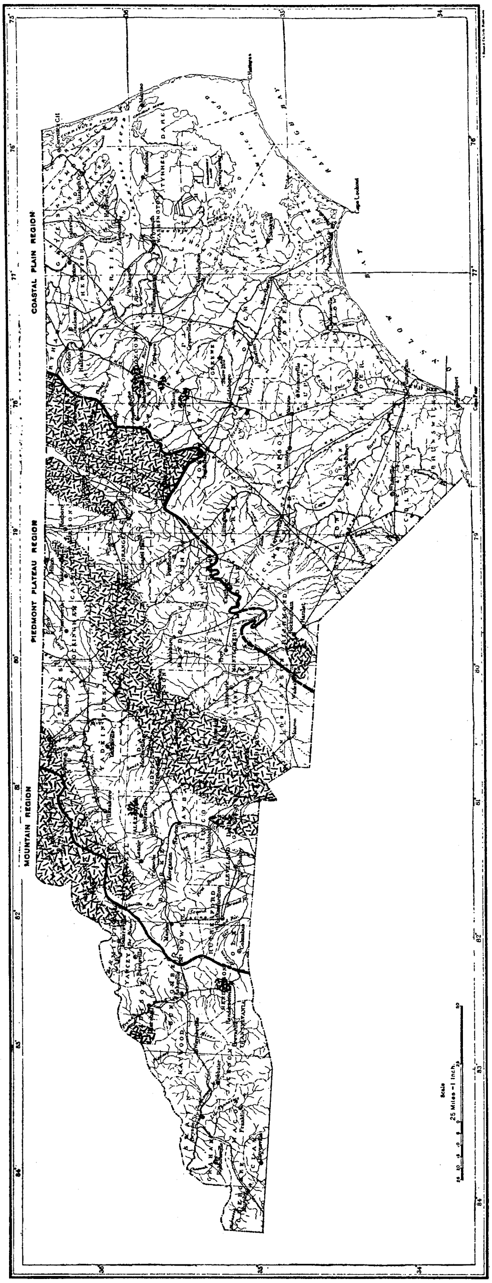
COASTAL PLAIN REGION
PIEDMONT PLATEAU REGION
MOUNTAIN REGION
Scale
25 Miles = 1 Inch

FIG. 1.

ite is extensively developed in many places, within the limits of the Piedmont Plateau, and it forms over many parts of the plateau one of the dominant rock types. The distribution of the principal granite areas of the state is shown on the accompanying map.

Over all parts of the state the rocks are profoundly decayed from weathering and, as a rule, are buried under a deep mantle of loose residual decay. Notwithstanding the extensive decay of the rocks, exposures of the moderately fresh granite are comparatively numerous and assume oftentimes very large dimensions. The granite forms unreduced residuals or ridges, as shown in Fig. 7, and it is further exposed in bowlders and ledges and flat-surface masses, both along the stream courses, and more or less remote from the streams on the interstream areas. (Figs. 2 and 3.)

Numerous quarries have been worked in the outcrops of granite throughout the state, and the stone has been used for all purposes for which granite is ordinarily adapted.

TYPES OF THE GRANITES.

Based on texture and structure three types of the granitic rocks are distinguished: (1) the massive even-granular (normal) granites; (2) the porphyritic granites; and (3) the banded or schistose granites—granite-gneiss. Field and laboratory study develops close similarity in the three types in mineral composition, and, with one exception, the even-granular and porphyritic textures represent different phases of the same rock-mass. Moreover, the granite-gneisses differ essentially from the massive granites, from which they have been derived, only in the pronounced schistose structure subsequently induced by pressure-metamorphism.

NORMAL GRANITES.

The even-granular granites have wide distribution, and they compose largely the bulk of the granites occurring in North Carolina. As a rule, they vary from fine- to medium-textured rocks, rarely coarse, and are of pink to gray color. With only a few exceptions, light to medium and dark gray is the prevailing color of the granites. Variation in structure is from massive to schistose rocks. They are mixtures of orthoclase and plagioclase feldspars and quartz, with a variable quantity of biotite and, in places, some additional hornblende as the characterizing accessories. The prevailing large amount of plagioclase feldspar in the rocks is a very noteworthy feature; rarely does this constituent sink to very subordinate proportions, but usually it is almost equal to, or even exceeds in amount, the potash feldspars; and only in a few of the sections studied does it entirely fail. In many of the areas the poverty of the rocks in the ferromagnesian silicates is a striking feature — a fact well illustrated in the large and important granite area in Rowan county, known as Dunn's Mountain, and its southwestern extension.

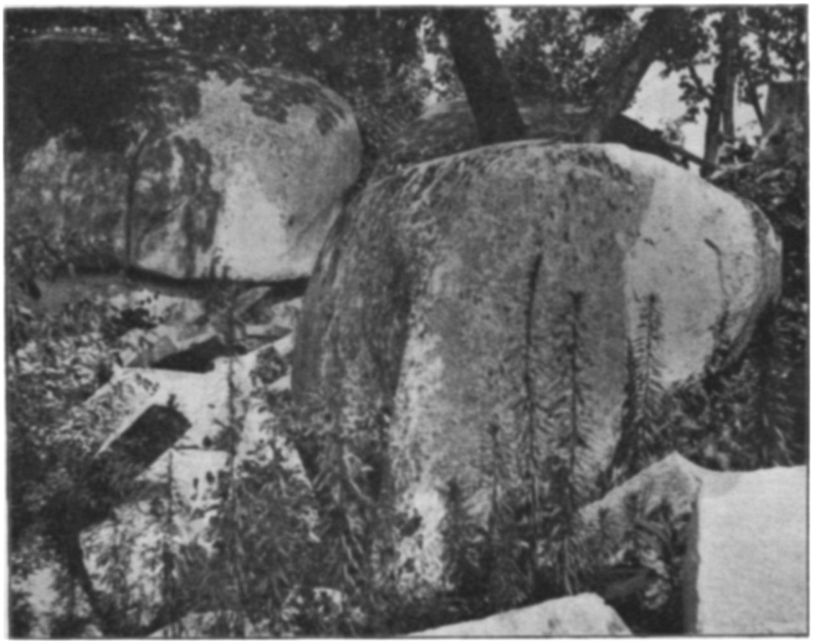

FIG. 2.—Granite bowlders on Dunn's Mountain, near Salisbury, North Carolina. Showing weathering along the joint-planes.

PORPHYRITIC GRANITES.

In all respects save that of texture the porphyritic granites are identical with the normal granites. They are usually coarser in texture than the even-granular rocks, but mineralogically the two are identical. With one exception, the two textures grade one into the other, representing different textural phases of the same rock-mass.

Porphyritic granites have wide distribution over the state in association with the even-granular phases of the rock. The most important areas are: (1) The Wadesboro-Rockingham area to the east of Charlotte and near the South Carolina line, extending over contiguous parts of Anson and Richmond counties. Over parts of this area the feldspars are colored a rich olive-green, representing apparently a superficial phenomenon caused by some form of surface alteration. A second difference noted is in the distribution and character of the biotite, which occurs in hexagonal plates of single or grouped individuals occupying distinct areas. (2) The Gastonia area in Gaston county, west of Charlotte. (3) The Mooresville area in Iredell county. (4) The Cabarrus county area, three miles southwest of Concord; and a second area in the same county in the vicinity of Landers station on the Southern Railroad, to the north of Concord and near the Rowan county line. The porphyritic rock occurring three miles southwest of Concord is quite different in appearance from that of any other area of porphyritic granite known in the state. Here the rock is uniformly coarse-textured and largely feldspathic, composed of large bluish-gray feldspars without pronounced crystal outline. The rock contains hardly more than a trace of groundmass, but is made up chiefly of the large feldspars wrapped about each other and closely interlocked. Biotite in small irregular shreds is one of the chief minerals in the scant groundmass. (5) The Salisbury area, which forms one of the most extensive belts in the state and is traced over parts of Rowan, Davie, and Forsyth counties. Smaller and less important areas of similar porphyritic granite have been noted in several other counties in the state.

Excepting the area three miles southwest of Concord in Cabarrus county, the porphyritic granite of the different areas mentioned above is closely similar in color, texture, and mineral composition. The groundmass is usually a medium-coarse gray granite composed of feldspar, quartz, and biotite. Some variation in the amount of the last constituent, biotite, is noted from place to place, resulting in a corresponding variation of color from light to dark gray. The porphyritically developed mineral is potash feldspar. As a rule, phenocrysts are marked in the different areas by idiomorphic outlines; and they are prevailingly of large size, measuring in extreme cases more than two inches long by one inch across. They are usually white, with pinkish ones not uncommon, and, in most cases, they contain more or less included biotite, frequently as large in size as that of the groundmass constituent. Under the microscope other inclusions of the groundmass constituents are contained in some of the phenocrysts. For this and other reasons elsewhere[1] stated by me, the phenocrysts of the Carolina porphyritic granites are regarded as having been formed largely, if not entirely, *in place* and not as often urged of *intratelluric* origin.

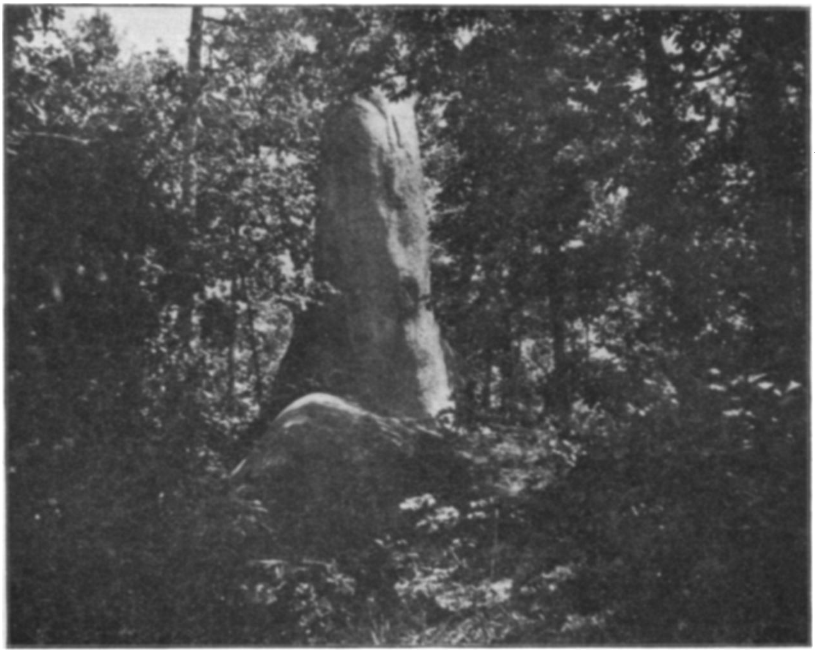

FIG. 3.—Granite pinnacle on the west slope of Dunn's Mountain, near Salisbury, North Carolina. Height of pinnacle more than twenty-five feet.

Generally the phenocrysts do not grade into the similar groundmass constituent, but they are, in most cases, conspicuously developed and are sharply defined from the groundmass feldspar. No marked or definite orientation has been observed among the phenocrysts in any of the areas, but in some of the exposures a slight tendency toward such was indicated. Flow structure in the groundmass is entirely absent from all of the areas studied.

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[1] "On the Origin of the Phenocrysts in the Porphyritic Granites of Georgia," JOURNAL OF GEOLOGY, Vol. IX (1901), pp. 97–122.

The porphyritic feldspars almost entirely fail in places, reappearing again within a short distance in their usual abundance and of conspicuous development. Over most of the areas the probable average ratio of phenocrysts to groundmass is approximately one to one, though extreme variations from this ratio in either direction occur. In the transitional phases of the rock where gradation from the porphyritic to the even-granular texture is observed, the phenocrysts are so few and are so widely scattered that the rock could hardly be termed porphyritic. On the other hand, in the porphyritic granite area three miles southwest of Concord, in Cabarrus county, the rock is composed almost entirely of the large feldspar individuals with very scant groundmass. In all cases the phenocrysts display good cleavage development and twinning on the Carlsbad law.

In many of the areas where outcrops of the fresh or moderately fresh granite are few, the rock can be traced almost as readily by its residual decay. The loose phenocrysts are scattered over the surface in places in a partially altered condition, often split into smaller fragments along the cleavage directions.

Relations between the porphyritic and the even-granular granite in the Mooresville area.—Like the other areas studied, the porphyritic and non-porphyritic granite of the Mooresville area differ from each other only in texture. Without going into detail descriptions of the two texturally unlike rocks, evidence is afforded at several places to the south and the southwest of Mooresville for regarding the one as intrusive in the other, and they do not represent separate facies of the same granite mass. Were the latter true, the line between the two rocks should mark a transitional zone from the porphyritic to the non-porphyritic granite, and not indicate in the few exposures examined a sharp contact. Furthermore, certain phenomena along this line would be difficult of explanation on this supposition. On the other hand, the evidence strongly suggests that the porphyritic rock is the oldest, and that the even-granular granite is intrusive in it. The field evidence supporting this belief may be summarized as follows: the sharpness of contact between the porphyritic and the non-porphyritic granite; the prevailing coarser texture of the porphyritic granite along the line of contact than that of the non-porphyritic rock; the banding in places along the contact; inclusions of the porphyritic granite in the even-grained granite; and the occurrence of probable apophyses of the fine-grained granite penetrating the porphyritic granite.

GRANITE-GNEISS.

True granite-gneisses are found in many places over the state, but perhaps the most typical areas are: (1) the unreduced residual locally known as Rockyface Mountain in Alexander county; (2) the area near Balfour station in Henderson county; and (3) the area on the Josey-Bogers places, three miles southwest of Faith in Rowan county. Wherever studied, the granite-gneisses are biotite-bearing, fine to medium texture, and closely resemble the massive granites in all essentials except that of schistose structure. Some effects of pressure-metamorphism are indicated either megascopically or microscopically in the granites of most of the areas studied. Granites of complete schistose structure were not definitely traced in any single area into entirely massive ones, although this may be the real condition in many cases. Lack of sufficient exposures of the rocks renders this uncertain in the North Carolina areas.

RELATIONS BETWEEN THE THREE TYPES OF GRANITE.

Enough description has been detailed above under the even-granular, porphyritic, and schistose granite to make fairly clear, so far as the field study is possible, the relations between the three texturally and structurally unlike granites here distinguished. It seems reasonably certain, so far as I have been able to interpret the field relations, that the porphyritic and non-porphyritic granites represent, with one or two possible exceptions different facies of the same granite mass. The principal exception noted above is that of the Mooresville area in Iredell county, where the normal granite is intrusive in the porphyritic granite.

The exact relations of the schistose (granite-gneisses) to the even-granular massive granites are less clear, and for lack of adequate exposures no definite statement can be made regarding whether the granite-gneisses are the more schistose transitional portions of a more massive granite stock. The completely schistose structure has nowhere been positively traced into the more massive granites, though this may be the true relation. That the areas of schistose granites mentioned above are the metamorphosed equivalents of the massive granites apparently admits of no reasonable doubt.

As pointed out in my study of the Georgia granites,[1] the exact relationship is an important one as bearing on the question of the relative age of these rocks. If the schistose rocks (granite-gneisses) cannot be traced into granites of more massive structure, but the two are separate and distinct, then clearly two periods of intrusion must be admitted, separated by an interval of intense pressure-metamorphism, which resulted in inducing the secondary schistose structure in the earlier massive granites, represented, if the postulate is correct, by the present granite-gneisses. If, on the other hand, the two represent phases of the same rock-mass in which the action of dynamic forces has been greater in some parts of the massif than in others, then the same age must be assigned them. As elsewhere shown in my study of the Georgia granites, the first condition apparently obtained, and the granites are not all of the same age, but at least two separate periods of intrusion of nearly identical material are indicated.

GRANITES OF THE COASTAL PLAIN REGION.

GENERAL CHARACTERS.

The line marking the contact between the Coastal Plain and the Piedmont Plateau formations in North Carolina is a very irregular one. It enters North Carolina from Virginia a short distance east of the Warren county line and crosses the state in a general southwest direction, passing into South Carolina a short distance southwest of Wadesboro. To the east of this line are the loose unconsolidated formations of the Coastal Plain.

In many places near the contact of the Coastal Plain formations with the rocks of the Piedmont Plateau, but falling well within the limits of the former, the thin veneer of loose unconsolidated sands and gravel has been stripped from the surface, mainly along the streams, exposing comparatively small, irregular, somewhat elongate areas of the crystalline rocks, composed either in part or in whole of granite. In such areas the general nature of the granite exposures is in the form of ledge and bowlder outcrops, and as flat-surface masses a short distance back from the streams.

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[1] "Granites and Gneisses of Georgia," *Bulletin No. 9-A*, Geological Survey of Georgia, 1902.

The inliers of crystalline rocks mark the eastward extension of the Piedmont crystallines beneath the Coastal Plain sediments. Some of the schists and gneisses composing parts of these areas are the metamorphosed equivalents of original igneous masses. They include both acid and basic types.

The principal granite areas of the Coastal Plain are exposed in Wilson, Edgecombe, and Nash counties to the east of Raleigh, and in Anson and Richmond counties in the vicinity of Wadesboro near the South Carolina line. They are composed of massive biotite granites, in one instance hornblende-bearing, which vary from fine even-granular to coarse porphyritic rocks of gray to pink color. The area to the north of Elm City, in the extreme northern part of Wilson county, contains some hornblende in addition to the biotite.

LITHOLOGICAL CHARACTERS OF THE GRANITES.

The Coastal Plain granites are described separately by areas in order to bring out more clearly their close similarity to the granites of the Piedmont region.

The Wilson pink granite area.—The rock is uniformly coarse-textured, of moderate pinkish-red color, and displays a pronounced porphyritic tendency. Feldspar is greatly in excess of the other minerals. The largest feldspar individuals measure one to two inches long. They are pinkish-red in color, exhibiting good cleavage development and twinned on the Carlsbad law. Microscopically the feldspar and quartz make up not less than 95 per cent. of the rock. A rough estimate indicates about 80 per cent. of the former and 15 per cent. of the latter. Of the feldspathic content about 50 per cent. is potash feldspar, most of which is orthoclase, with but little microcline; and 30 per cent. is plagioclase in very large, finely striated laths, whose extinction angles measured against the twinning bands indicate albite. Biotite is but sparingly present in the rock and is largely altered to chloride. Occasional small grains of magnetite and scattered inclusions of prismatic apatite, with some secondary muscovite, kaolin, and calcite, complete the list of accessories.

The weathered surface of the granite is light in color. The feldspars are dull and opaque, and have lost much of their decided pinkish-red color, so characteristic of the same constituent in the fresh rock.

The Elm City area.—The Elm City granite is strongly contrasted with the Wilson pink granite described above. It is much finer in texture, of gray color, and contains more biotite and quartz than the Wilson pink granite. Feldspar predominates and consists of the potash varieties and much striated acid plagioclase. Extinction angles measured on the plagioclase correspond to an albite of the composition $Ab_{12}An_{1}$. Areas showing alteration to kaolin and muscovite cloud some of the feldspars. Micropoikilitic structure is strongly developed in some of the larger individuals of potash feldspar, the inclusions of which consist of large microscopic grains of quartz and striated feldspar. Quartz is of the usual kind, forming distinct areas of an interlocking finer mosaic. Biotite is distributed through the sections as small plates of brown color and strong pleochroism, bleached to green on alteration, and is further altered to chlorite and some epidote. In one of the thin sections a few additional small crystals of compact hornblende, showing the usual development of the prismatic cleavages, occur. The principal accessories include zircon, apatite, a little pyrite, titanite, and ilmenite. The granite shows evidence both megascopically and microscopically of dynamic metamorphism, manifested, in places, by a rather pronounced schistose structure.

The quarry opening indicated penetration of the granite by a dike of very finely schistose amphibolite, closely jointed and containing many disseminated small grains of pyrite. Additional quartz veins penetrate the granite, wrapped, in cases, by films of thin layers of hornblende. The surfaces of the joints are slickensided, coated with a thin veneer of yellowish-green mineral substance, probably epidote in part. Considerable epidotization characterizes the rock in places.

The Rocky Mount area.—Westward from Rocky Mount the granite is associated with an irregular but large body of crystalline schists which were derived in part from original igneous rocks. Contacts between the granite and the schists were nowhere observed, but the field evidence clearly suggests that the granite is the younger rock.

Pegmatite veins, ranging from a fraction of an inch to more than six inches across, composed of pinkish feldspar and quartz, with a very subordinate amount of biotite, penetrate the granite. Nearly all gradations from those veins containing mostly feldspar to those containing mostly quartz occur. In some of the veins the quartz forms a narrow central band in the feldspar. Others still are banded with a fine-textured granite of the same mineral composition as the inclosing rock. Some of these are true veins of segregation; others are less certain of interpretation, mainly because of the lack of exposures for examining them.

Megascopically the rock is somewhat unlike that described above, the Elm City area. It is entirely massive, of medium texture, and gray color. In mineralogy it differs from the Elm City rock in the entire absence of hornblende, and in the presence of only a slight amount of plagioclase. Orthoclase and microcline have nearly equal distribution. Quartz forms a fine mosaic, occupying distinct areas. Intergrowths of micrographic structure are rather abundantly distributed through the sections in irregular small areas. The accessory minerals are biotite, chlorite, epidote, apatite, zircon, and magnetite.

The Wadesboro-Rockingham porphyritic granite area.—This is a large area of porphyritic granite lying partly in Anson and partly in Richmond county, near the South Carolina line and to the west of Charlotte. About one mile east of the westernmost exposure of the granite the Triassic sandstones first appear, overlying unconformably the crystalline schists. Between the granites and the sandstones is an area of variable crystalline schists, principally micaceous and quartz schists. Between Rockingham and the easternmost outcrops of the granite the rocks are concealed by Coastal Plain sands and afford no evidence of the nature of the underlying crystallines. In and about the town of Rockingham the principal outcrops indicate a greenstone schist much crushed and fractured, and strongly suggests derivation from an original basic igneous rock. The schists to the east and west of the granite mass must be regarded as older in age than the granites, and they form the country rock into which the granite was intruded.

Exposures of the granite are in the nature of huge bowlders, ledges, and flat-surface masses. Sections of the fresh and weathered granite are seen to advantage in the cuts along the Seaboard Air-Line Railroad to the east and west of Lilesville.

It is a coarse-grained porphyritic biotite granite of gray color, with pinkish and yellow tones characteristic in places. The groundmass is medium coarse-textured, dark gray, granite, containing, as a rule, much biotite. This is subject, however, to some variation. In the railroad cut one and a half miles west of Lilesville the biotite has quite a different occurrence and distribution in the granite from that of any other exposure examined in the area. Here the biotite is usually in sharp idiomorphic hexagonal plates, distributed through the rock as single individuals and aggregates, which occupy distinct areas. Elsewhere it occurs as irregular shreds crowded close together and freely distributed through the groundmass.

The phenocrysts are composed of potash feldspar, showing marked cleavage development and twinned on the Carlsbad law. They are usually of a pinkish hue, and may be either idiomorphic or allotriomorphic in outline; and, they contain usually some included biotite. The ratio of phenocryst to groundmass is variable, but will probably average about one to three.

The principal minerals are quartz, orthoclase, microcline, plagioclase (near oligoclase), biotite, chlorite, apatite, zircon, magnetite, and a few other less common accessories. Microcline may fail in some sections and be present in large proportion in others. Plagioclase is a constant constituent and is usually present in large amount.

GRANITES OF THE PIEDMONT PLATEAU.

GENERAL CHARACTERS.

The Piedmont region in North Carolina is composed of a number of geologic belts, approximately parallel to each other and crossing the state in a general northeast-southwest direction. These belts are composed, as a rule, of unlike rocks, probably of different ages. A variety of granites are found within the limits of the Plateau region; always biotite-bearing, with additional hornblende in some areas, and muscovite when present in very subordinate amount. In texture, variation is from even-granular to porphyritic; and in structure from massive to schistose. As a rule, some shade of gray prevails, though pink is largely characteristic of certain areas. The Plateau granites are described under the following belts: The Northeastern Carolina Granite Belt, the Main Granite Belt, and the Western Carolina Gneiss and Granite Belt.

THE NORTHEASTERN CAROLINA GRANITE BELT.

This area comprises a part or the whole of five counties located in the extreme northeast part of the Piedmont region, extending northward from Raleigh. With but few exceptions, the granites of this belt are partially schistose in structure. The characterizing accessory, biotite, is variable in quantity; imparting accordingly either a light or a dark gray color to the rock. In places the feldspars are of a pronounced pinkish hue and with the subordinate amount of biotite present, the rock assumes more or less of a mixed pinkish-gray color. The granites are usually even-granular in texture, though the porphyritic tendency is somewhat emphasized in places. They do not differ essentially in mineralogy, although hand specimens from different areas in the belt may bear no resemblance to each other.

LITHOLOGICAL CHARACTERS.

Two areas, differing somewhat widely in the hand specimens, but which may be regarded as representative of the granites of the belt as a whole, are selected for description, in order to make clear the general characters of the rocks as a whole. These are the Raleigh area in Wake county and the Greystone area in Vance county.

The Raleigh area.—Studied in the quarries opened within the eastern limits of the city of Raleigh, the rock is a fine even-textured, medium-gray, biotite granite-gneiss, completely interlaced by intersecting pegmatites. The principal minerals are quartz, orthoclase, microcline, acid plagioclase near oligoclase, brown biotite, muscovite, zircon, apatite, chlorite, and epidote. Quartz is of the usual kind, and is often intergrown with feldspar in micrographic structure, clearly indicating that its period of formation began before that of the feldspar closed. In addition, it occurs with other minerals, especially plagioclase, in the form of inclusions in the larger potash feldspar individuals developing micropoikilitic structure. Microcline nearly equals orthoclase in quantity, and plagioclase is hardly less than both. Carlsbad twinning is sometimes observed in the feldspar.

Biotite is brown in color, strongly pleochroic, and is largely altered to chlorite and some epidote. An occasional shred of muscovite is intergrown with the biotite. The other accessory minerals present no noteworthy features.

The larger feldspar and quartz individuals are partially or entirely surrounded by finer mosaics of the same minerals, denoting peripheral shattering from dynamic forces. Strained shadows in the minerals are further characteristic of the same pressure effect.

In the northern part of Wake county, in the vicinity of Rolesville, a light pinkish biotite granite occurs, which differs from the Raleigh granite in the hand specimen, but does not differ essentially in mineralogy. Plagioclase is very variable, equaling in some sections the potash feldspar and nearly failing in others. Orthoclase and microcline are in nearly equal proportion. Small irregular areas of micrographic intergrowths of quartz and feldspar are quite abundantly distributed through the thin sections.

The Greystone area.—The Greystone quarries are among the largest in the state. The typical Greystone granite is medium gray in color, of pronounced schistose structure, and in texture varies from fine- to medium-grained. More or less tendency toward a poorly defined porphyritic texture is manifested in some parts of the area. The feldspars are partly of a pronounced pinkish hue, which impart a slightly mixed pink and gray color to the rock. In some respects hand specimens from the Raleigh and Greystone areas bear some resemblance to each other; in others they are strikingly different. In mineral composition they are essentially identical.

The principal minerals are quartz, orthoclase, microcline, microperthite, a little acid plagioclase near oligoclase, biotite, apatite, zircon, chlorite, muscovite, and kaolin. Microscopically the most noteworthy feature of the granite in this area is the very small amount of plagioclase present, which entirely fails in some of the thin sections. When present, the plagioclase individuals show broad twinning bands having extinction angles near that of oligoclase. Microcline is a constant constituent, and, though somewhat variable, it may equal in amount the orthoclase. Intergrowths of orthoclase with a second feldspar as microperthite are fairly characteristic. Simultaneous crystallization of the quartz and a part of the feldspar is clearly indicated in micrographic intergrowths of the two minerals, and in the development of the micropoikilitic structure in the potash feldspars. The drop-like inclusions in the feldspar consist of quartz and other feldspar species, principally plagioclase. The feldspars are partially clouded from irregular patchy areas of alteration to minute scales of muscovite and kaolin. Carlsbad twinning is not uncommon among the feldspars. Biotite is in irregular shreds of brown color and strong pleochroism, and in many of the sections it is extensively altered to chlorite. Occasional shreds of muscovite are intergrown with the biotite. Zircon inclusions are somewhat common to the three principal constituents, feldspar, quartz, and biotite. The effects of dynamic forces are manifested in the thin sections by peripheral shattering and recrystallization, and in strained shadows in the principal minerals, quartz and feldspar. Megascopically the arrangement of the minerals along approximately parallel lines is manifested in the development of a thinly schistose structure.

The granite areas farther north in Warren county bear no resemblance in the hand specimens of the rocks to the Raleigh and Greystone granites, though they differ only slightly in mineralogy. In one exposure near Warren Plains biotite entirely fails, and muscovite is substituted. To the north of this locality biotite again assumes the rôle of principal accessory with some muscovite present, and the granite has abundant garnets scattered through it.

The granite of the Louisburg area in Franklin county resembles somewhat that of the Greystone quarries in the hand specimens, except that the former is entirely massive. Plagioclase occurs only sparingly in the granite of the Louisburg area, and microcline and microperthite entirely fail. In other essentials the granite from the two areas is similar. Over parts of the Louisburg area as well as at Greystone a slight porphyritic tendency is indicated in the rock.

THE MAIN GRANITE BELT.

GENERAL CHARACTERS.

This belt is an irregular one in width, occupying the central part of the Carolina Piedmont region, and extending from near the Virginia line in Person county, North Carolina, in a southwest direction across the state into Mecklenburg and Gaston counties, along the South Carolina line. The whole or a part of a dozen counties are included within the limits of this belt. Granite, either massive or schistose in structure, forms the principal rock type over the belt.

Texturally two distinct phases of the granite are developed, an even-granular and a porphyritic granite, both of which have wide distribution. With the single exception discussed on p. 381, the two texturally unlike rocks represent phases of the same granite mass. In all other essentials the normal and the porphyritic granites are closely similar.

Over many parts of the belt the granite manifests some evidence of the effects of intense dynamic forces, in many instances resulting in the partial or complete development of a secondary schistose structure. In thin sections of the rock from those areas in which the granite megascopically appears entirely massive, evidence more or less pronounced of pressure-metamorphism is shown.

The rocks are usually colored some shade of gray, light or dark, in accordance with the proportion of the ferromagnesian mineral present. In some a pronounced pink prevails, and the biotite, which is in very small amount, is not noticeable in the rock. Hardly without exception, the rocks are biotite granites, containing in several places additional hornblende, which is the principal accessory in the granite of several areas in Mecklenburg county, although biotite does not entirely fail in these. Muscovite as a primary constituent is sparingly developed, in a few localities, in association with biotite.

Microscopically the granites are essentially the same in mineral composition as those described above and to the east of this belt. Plagioclase feldspar is a nearly constant constituent, though subject to some variation. At times it exceeds the potash feldspar in amount, and it does not entirely fail in but one or two of the thin sections. Optically it corresponds to a very acid plagioclase, albite or oligoclase, or both. Orthoclase and microcline are both usually present in the sections, oftentimes in nearly equal proportions, though the microcline is subject to considerable variation. Simultaneous crystallization of the quartz and a part of the feldspar is usually indicated in the distributed areas of micrographic intergrowths of the two minerals and in the development of micropoikilitic structure in some of the feldspars, the inclusions consisting largely of quartz and plagioclase. The usual accessory minerals common to granite are noted in the thin sections of the rocks.

The porphyritic granites have been previously described on p. 378, and it is only necessary here to again emphasize the fact that they are in every case biotite-bearing without hornblende, and are the equivalents in mineral composition of the even-granular granites. Three areas, representing different types of the normal granites, are separately described below. These are: the Dunn's Mountain area in Rowan county; the Mooresville area in Iredell county; and the occurrence of hornblende granite in Mecklenburg county to the north and the south of Charlotte.

LITHOLOGICAL CHARACTERS.

The Dunn's Mountain area.—This is a granite ridge twelve to fourteen miles long, having a general northeast-southwest trend and located a few miles southeast of Salisbury. Numerous quarries have been worked over many parts of the ridge which afford excellent opportunity for obtaining fresh specimens of the rock. Two distinct types of the rock are recognized; (*a*) a very light gray, nearly white, and (*b*) a pronounced pink. The two are intimately associated. They have the same mineral composition and texture, and are apparently phases or differently colored portions of the same rock-mass. The texture is medium even-granular and is fairly uniform. Dynamic metamorphism has manifested itself over all parts of the ridge in a faintly marked schistose structure, and on the Josey-Bogers places three miles southwest of the village of Faith the rock is completely thinly schistose. Over the north slope of Dunn's Mountain proper pronounced shear zones of the crushed and laminated rock, narrow in width, are developed in the granite mass, striking N. 55°–70° E. The rock surfaces are slickensided, accompanied by considerable epidotization.

The component minerals are quartz, orthoclase, microcline, at times microperthite, abundant plagioclase, a little biotite, magnetite, chlorite, epidote, titanite, rutile, and occasional garnet. The granite is largely a mixture of feldspar and quartz, with scant biotite as the third principal component. One of the most striking features in the mineral composition of the rock is its poverty in the ferromagnesian mineral and the excessive plagioclase, which latter constituent exceeds the potash feldspars in all the thin sections examined. Plagioclase is in large, stout, rudely prismatic forms, polysynthetically twinned, and corresponds in optical properties to albite and very acid oligoclase. Both orthoclase and microcline occur, the latter very variable in quantity, being reduced to one or two grains in some sections and in fairly good proportion in others. Microperthite is distributed in small amount through some of the sections. Carlsbad twinning is observed, but it is not so frequent as in some of the granites from other localities in the state. In the pink phase of the rock the feldspars are usually filled with closely crowded dust-like particles of a reddish-brown color, which probably represent some form of iron oxide. Biotite, when present in the thin sections, is of the usual kind, and is distributed through the rock in small, very irregular shreds, altered largely to chlorite. Quartz occupies well-defined areas between the larger feldspars, forming an aggregate of interlocking fine grains, in which feldspar may or may not appear.

Crushing and recrystallization from the action of intense dynamic forces are strongly emphasized in all of the thin sections. Finer mosaics of quartz and feldspar border the larger individuals of the two minerals and fill the interspaces. The larger laths of plagioclase are fractured and broken, and in many instances curved and bent, with irregular fractures and strained shadows common to the other essential components.

The Mooresville area.—The porphyritic granite of the Mooresville area has been previously described on pp. 380 and 381. Attention is here directed to the even-granular granite, which is a very fine textured rock of dark gray color. It is strongly contrasted with that of the Dunn's Mountain area described above. Orthoclase and microcline are in nearly equal amount. Unlike the other areas, plagioclase is very sparingly present, not more than a few grains being observed in any one of the sections. Some microperthite occurs. Biotite of deep brown color and strong pleochroism is uniformly distributed in large amount through the sections, altered principally to chlorite, a colorless mica, and occasional epidote. Areas of micrographic structure are abundantly distributed through some of the sections, clearly indicating the overlapping of the periods of formation of the quartz and feldspar. Pleochroic titanite in crystals and grains is quite freely developed in one of the sections. Inclusions of apatite and zircon are fairly constant.

The Mecklenburg county areas.—Biotite-bearing hornblende granite occurs one mile east of Davidson in the extreme northern part of the county, and again five to six miles south of Charlotte in the extreme southern part of the county. Hand specimens of these granites are entirely different from, and bear no resemblance whatever to, those of the types previously described. They are of medium texture and gray color, and in the locality south of Charlotte a few bowlders have been worked off for monuments. Much plagioclase is present in association with the potash feldspar. Compact hornblende with strong cleavage development is the principal ferromagnesian mineral present. It is accompanied by more or less biotite of the usual kind, which varies greatly in amount.

The granite to the east of Davidson contains large lath-shaped crystals of the hornblende distributed through it, which measure in extreme cases as much as one and a half inches in length. All gradations in the size of the hornblende individuals down to the smallest grains occur. Chlorite is one of the chief alteration products of the ferromagnesian constituent. Much titaniferous magnetite occurs along with some of the usual minor accessories.

THE WESTERN PIEDMONT GNEISS AND GRANITE BELT.

GENERAL CHARACTERS.

The principal rocks of this belt are gneisses of variable mineral composition. A residual of biotite granite-gneiss, closely resembling in the hand specimens and in mineral composition the well-known Lithonia area of granite-gneiss in Georgia,[1] occurs in Alexander county near Hiddenite. Large areas of biotite granite of medium to coarse texture are located in the northern part of the belt. The Mount Airy area in Surry county, near the Virginia line, may be taken as the type.

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[1] "Granites and Gneisses of Georgia," *Bulletin No. 9–A*, Geological Survey of Georgia, 1902, pp. 125 ff.

LITHOLOGICAL CHARACTERS.

The Mount Airy granite area.—Quarries are worked one and a half miles north of the town of Mount Airy, on a ridge slope of continuously exposed granite. In mineral composition the Mount Airy granite does not differ essentially from some of the types already described, though hand specimens of the rock bear little or no resemblance to each other. The usual granitic minerals are noted, such as quartz, orthoclase, microcline, plagioclase, biotite, muscovite, zircon, apatite, epidote, chlorite, and magnetite. In addition to these, several grains of allanite have been noted in one of the thin sections. Orthoclase is in excess of the microline in all of the sections examined, accompanied by a larger proportion of finely striated acid plagioclase. Zonal growth and Carlsbad twins are beautifully developed in some of the feldspars. Biotite of brown color and strong pleochroism is the principal accessory, and is altered into chlorite, a colorless mica, and some epidote. Much secondary muscovite derived from the alteration of the feldspar and biotite is present. The large individuals of quartz and feldspar indicate peripheral shattering in finer-grained mosaics of the two minerals filling the interstices.

GRANITES OF THE APPALACHIAN MOUNTAIN REGION.

GENERAL CHARACTERS.

Areas of granite and granite-gneiss resembling essentially in mineral composition some of the granite types described above are known over parts of the mountain region of the state. Those of the extreme northwest part of the state have recently been mapped and described by Keith.[1] Since, with perhaps a single exception, those of the other parts of the mountain region are not unlike certain types already described in this paper, only one type is of special interest here, namely, unakite, which occurs in the vicinity of Hot Springs,

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[1] *Geologic Atlas of the United States,* ' Cranberry Folio, North Carolina–Tennessee." U. S. Geological Survey, 1903.

Madison county, North Carolina, and the contiguous part of Cocke county, Tennessee.

LITHOLOGICAL CHARACTERS.

The Unakite area.—The unakite area in Madison county, North Carolina, and Cocke county, Tennessee, is the type locality first described by Bradley in 1874. I quote in full Bradley's description:[1]

> This name [Unakite] is proposed for a member of the granitic series, from the Great Smoky Mountains, a portion of the Unaka range of the Blue Ridge, which range forms the boundary between Tennessee and North Carolina. The specimens thus far seen are from the slopes of the peaks known as "The Bluff," "Walnut Mountain," and "Max's Patch," Cocke county, Tenn., and Madison county, N. C. The rock is said to occur also in Yancey county, N. C., but in a comparatively inaccessible region.
>
> The character relied upon for the separation of the species is the constant replacement of the *mica* of common granite, or the *hornblende* of syenite, by epidote. The amount of this ingredient present is quite variable, in some cases even exceeding one-half of the whole mass. The feldspar present is orthoclase, of various shades of pink, forming from one-fourth to perhaps one-third of the whole. The quartz is mainly white, but occasionally smoky; its isolated portions form but a small part, say one-fourth, of the mass; it is veined in structure, but this is probably not a constant character. Small grains of magnetite are scattered through the rock, but not so thickly as in many granites. No other ingredients have as yet been detected. Mr. G. W. Hawes has determined the specific gravity at 2.79. The rock is very compact and takes a high polish, and will doubtless prove to be a valuable material for ornamental architecture.
>
> The deep weathering of all the rocks of the Southern Appalachians has caused the covering of most of these mountain slopes with deep beds of débris, which conceal most of the solid outcrops; and the dimensions of the bodies of uanakyte are therefore as yet unknown. Apparently forming part of the same series, there are heavy beds of specular iron ore; and the whole series is referred with little doubt to Archaean age.

The outcrops of the granite over the surface, as traversed by me, indicate an area of about twenty-four square miles, lying mostly in Madison county, North Carolina, beginning about five miles southwest of Hot Springs. Further detailed work will probably extend the boundaries of the area considerably beyond those mentioned here.

Two types of the granite occur in the area, both of which contain epidote. The bulk of the granite or main body of the rock is a dark pinkish-green epidote granite of medium-coarse texture and fairly schistose or foliated in structure. This is not the unakite proper, but may be properly designated the epidote-bearing rock. It varies from a typical granite in which quartz is present in the usual amount to a nearly quartzless rock of the same color and texture. The unakite proper is a coarse-textured rock composed of yellow-green epidote, dull pink or red feldspar, and quartz. It is not entirely uniform in color and composition, but it grades into a highly feldspathic rock of pink color on the one hand, and an epidotic rock of yellowish-green color on the other, with still a third gradation observed into pure quartz.

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[1] *American Journal of Science*, Vol. CVII (1874), pp. 519, 520.

Thin sections of the epidote-bearing granite show the principal minerals, quartz, orthoclase, and microcline, in about equal proportion, a little plagioclase, biotite, epidote, chlorite, rutile, zircon, apatite, magnetite, pyrite, and kaolin. The epidote distributed through the sections is wholly a secondary product derived from the interaction of the biotite and feldspar. It occurs in the form of minute microscopic granules thickly crowded together, in many cases lying next to the biotite. The mass of granules, when forming an area large enough to be visible megascopically, appears as a single large epidote individual rather than as separate microscopic granules. Besides epidote, the feldspars are altered to a colorless mica, and in some instances the original mineral is completely obscured by the alteration products. At times the feldspars are much fractured and broken, the fissures of which are now filled with another mineral substance. Sometimes alteration has progressed along the lines of fracture in the feldspar, and patches and stringers of deep-green mica line them. Thread-like filaments of rutile, broken into minute segments, are crowded together in the quartz anhedra. Some peripheral shattering from pressure-metamorphism is indicated in narrow zones of fine-grained mosaics of quartz and feldspar partially surrounding these two minerals. Strained shadows and fractures are common to both the larger quartz and feldspar grains.

The principal difference microscopically between the unakite and the epidote-bearing rock is that of extreme epidotization of the former, further marked by the absence, in those sections studied, of both plagioclase and ferromagnesian minerals, identified as such.

Since both of these minerals are present in the epidote-bearing rock, their absence in the unakite is very likely due to extreme epidotization of the unakite, completely altering both the mica and the plagioclase in case these were originally present. That mica or some ferromagnesian constituent was originally present in the unakite it seems necessary to assume in order to meet the requisite conditions of formation of so large a quantity of epidote.

The principal component minerals in the unakite are quartz, orthoclase, epidote, rutile, titaniferous iron oxide, and secondary muscovite, kaolin, and leucoxene. Rutile is contained in the quartz anhedra as inclusions of hair-like filaments. The orthoclase has a pronounced pink color in the hand specimens which disappears in the thin sections. Here, as in the epidote-bearing rock, conclusive evidence is furnished of the wholly secondary nature of the epidote. Its largest occurrence is in the replacement of the feldspar individuals in the form of a complete mass of microscopic granules, entirely obscuring in many cases the feldspar substance, but preserving the outline of the latter in a more or less perfect manner. The granular masses of epidote appear in the hand specimens as single large epidote anhedra. Other feldspar individuals show patchy areas and scattered granules of epidote over their surfaces. Still a third occurrence of the epidote is in irregular broken bands or stringers, following the network of fractures in both the feldspar and the quartz. In some cases these stringers ramify outward from the granular masses of epidote, replacing the feldspar. Again the granular masses often show irregular margins traced outward from the more compact mass into scattered granules of epidote. All gradations between these occurrences of the epidote are traced. Very little of the feldspar is entirely free from epidotization.

Some peripheral shattering accompanied by much fracturing of, and strained shadows in, the quartz and feldspar, indicating the effects of dynamic forces, characterizes to some degree all of the thin sections.

It seemed quite conclusive, from the different exposures studied of the unakite in its relations to the inclosing epidote-bearing granite, that the unakite is of distinct vein character which can be referred very likely to the segregation type.[1] It does not exist in quantity large enough to be worked over any part of the area traversed by me; hence it has only scientific interest.

STRUCTURAL FEATURES OF THE GRANITES.

MEGASCOPIC STRUCTURES.

Joints.—With possibly one or two exceptions, the Carolina granites are characterized by a strong development of the jointed structure, the planes of which break the rock into polygonal blocks of different sizes, as indicated in Fig. 4. The most noteworthy exception is that of the extensive granite area near Mount Airy, in which no visible jointing is apparent. Careful measurements of the joint-planes were made in all the granite openings visited in the state, and the results can be summarized as follows: Those joints whose planes lie in the northeast and the northwest quadrants respectively, and composing the major jointing; and two minor sets whose planes strike east-west and north-south. In the northeast and the northwest quadrants the limits of variation in the strike of the joint-planes are N. 10° E. or W., to N. 80° E. or W. Out of the total number of joint-planes measured fifty-six lie in the northeast quadrant and forty-five in the northwest quadrant; while nineteen strike in a north-south direction, as against sixteen having an east-west strike.

Slickensides.—As a rule, the joint-planes show smooth, more or less polished and striated surfaces, indicating considerable movement in the rocks since the formation of the joints. Striæ are developed in a thin coating of yellow to yellowish-green mineral substance, derived from certain minerals in the granite and produced by the rubbing together of the two sides along the plane.

Schistosity.—Between the perfectly schistose granites (granite-gneisses) and the perfectly massive granites, nearly all gradations in schistose structure are shown. Not in the same mass, however; for not in a single instance has such been observed. Whether the entirely schistose structure is more or less sharply and completely separated from the massive, or whether they grade from one into the other, it is impossible to say, owing largely to the lack of sufficient exposures of the rocks. Even in most of those granites which megascopically appear massive, more or less evidence is shown in the thin sections of the effects of dynamic forces, in peripheral shattering or granulation, and in strained shadows and fractures in the quartz and the feldspar. In such cases no semblance of rearrangement of the mineral components along certain definite lines appears.

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[1] Since this paper was written, PHALEN ("A New Occurrence of Unakite," *Smithsonian Miscellaneous Collections*, Vol. XLV (1904), pp. 306–16) has published a preliminary paper on the occurrence and petrography of unakite at Milams Gap in Virginia. The rock in which the unakite occurs in the Virginia locality is reported by the author to be hypersthene akerite. The epidote of the unakite is secondary, replacing pyroxene and feldspar, both plagioclase and orthoclase. The author believes the unakite has originated from the akerite by hydrometamorphism, aided perhaps by dynamic disturbances.

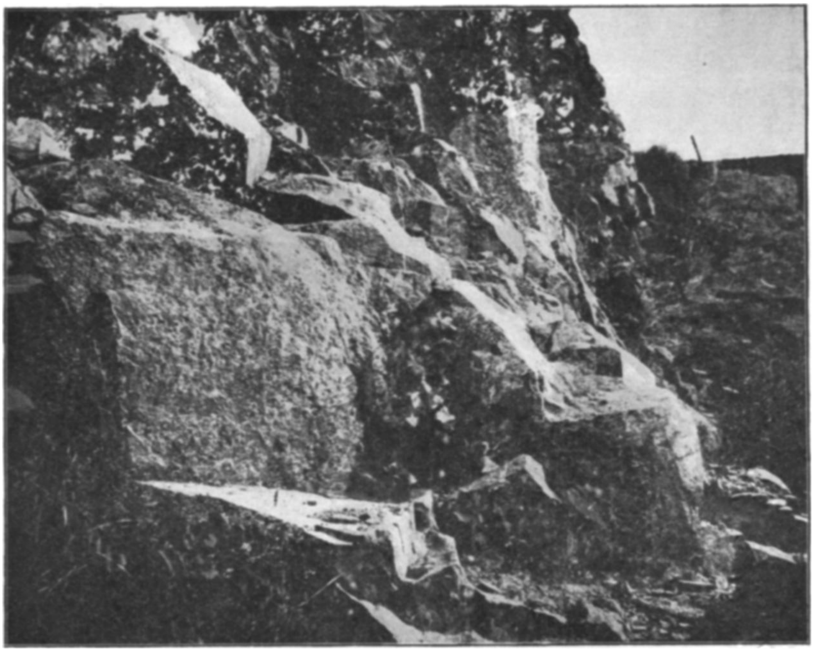

FIG. 4.—Vertical jointing in granite. City of Charlotte quarry, North Carolina.

Basic inclusions.—The granite in many of the quarries contains inclusions of basic segregations which were formed from the cooling magma. These are invariably of darker color and finer grain than the inclosing granite, and are entirely massive. Sections from them resemble closely the inclosing granites in mineral composition, except that biotite is greatly in excess, while quartz may be somewhat diminished in quantity. It frequently requires the closest examination, megascopically, to detect more of the minerals than the dark ferromagnesian components, except in a few cases where an occasional porphyritically developed feldspar has formed, so fine-grained and very dark in color are the schlieren.

Their distribution in the granites is subject to much variation. From some quarries they are entirely absent, in others they are developed only occasionally, and in others still they are so abundant as to exclude the rock from use in certain higher grades of work. Variation in size is from a fraction of an inch to more than a dozen inches across. Irregularity of outline is usually characteristic of them, variation being from roughly oval-shaped and round to greatly elongated areas, one of whose diameters is several times that of the second.

MICROSCOPIC STRUCTURES.

Peripheral shattering or granulation and recrystallization has already been mentioned. It is only necessary here to call attention briefly to two fairly constant microstructures in the granites, observed in similar rocks elsewhere, namely, granophyric and micropoikilitic.

Granophyric structure.—Granophyric intergrowths of feldspar and quartz are either sparingly or abundantly developed in most of the thin sections examined of the Carolina granites. They display the usual form and development observed in granites in general. So far as it was possible to determine, the intergrown feldspar may be either of the potash or plagioclase species. The areas may be inclosed by the larger feldspar individuals, or they may be formed at or near the contact between the larger feldspar and quartz grains. Their character clearly indicates simultaneous crystallization of the two minerals—an overlapping in the period of formation of the feldspar and quartz. This conclusion finds added confirmation in the micropoikilitic structure described next below.

Micropoikilitic structure.[1]—In thin sections of the granites from both North Carolina and Georgia, certain of the large feldspar individuals are frequently filled with crystals, or grains of other minerals, arranged without reference to one another or to their host. Hardly without exception, the inclosing mineral is a potash feldspar, and the included minerals are quartz and plagioclase, with an occasional shred of biotite. In the phenocrysts of the porphyritic granites this order is frequently reversed, and biotite is often inclosed in largest amount. Variation is from several scattered included grains in the feldspar to hosts fairly filled with the inclusions. The inclosed quartz grains are rounded in outline, drop-like in form, while the striated plagioclase may vary from similarly rounded grains to lath-shaped forms.

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[1] G. H. WILLIAMS, "On the Use of the Terms Poikilitic and Micropoikilitic in Petrography," JOURNAL OF GEOLOGY, Vol. I (1893), pp. 179 ff. This paper contains numerous references to published accounts of this structure.

Because of its occurrence in devitrified glasses, Williams[1] ascribed in some cases a secondary origin to the very abundant micropoikilitic structure in the ancient acid lavas of South Mountain, Pennsylvania, and Maryland. There is no evidence for regarding the structure in the Carolina and Georgia granites of other than primary origin—a fact which aids, as I interpret it, in formulating the order of separation of the feldspars and quartz from the magma. When viewed in connection with the granophyric structure described above, the two microstructures furnish conclusive evidence of the overlapping in the period of crystallization in the potash and plagioclase feldspars and the quartz in the southern granites. A tendency was noted in many of these sections toward maximum development of the two structures in the same thin section. This seeming association was by no means a constant feature, for many sections in which granophyric intergrowths were present indicated the entire absence of the micropoikilitic structure.

INTERSECTING DIKES AND VEINS.

Genetically the intersecting materials are of two kinds, true dikes and true veins. These contrast quite strongly in some instances, and in all cases they show differences to some degree in both texture and composition.

BASIC IGNEOUS DIKES.

Dikes of basic igneous rocks, principally diabase or its altered form, were observed penetrating the granites in most of the important areas in the state. A majority of these were noted from surface exposures of the rocks, and hence more or less deeply decayed, while many of them were exposed in the quarry openings, which afford excellent opportunity for observing their relations to certain structural features of the granite discussed below (Fig. 5). In several quarries in widely separated parts of the state a series of some half-dozen or more dikes were observed. Where exposed in the quarries, none of the dikes exceed fifty feet across, and usually they are less than four feet.

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[1] G. H. WILLIAMS, *American Journal of Science*, Vol. XLIV (1892, 3d S.), p. 482.

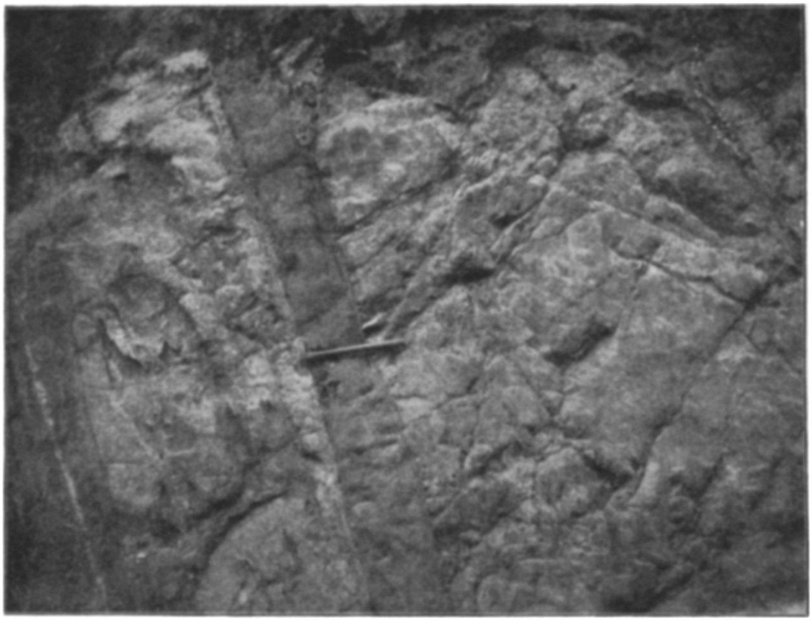

FIG. 5.—Dike of diabase penetrating granite in the city of Charlotte granite quarry, North Carolina. Part of a second dike is visible in the extreme left of the view.

Lithologically two types are indicated. The first is usually an unaltered massive diabase, the thin sections of which show under the microscope the essential minerals and structure of diabase. The pyroxene in this type may be considerably altered in some of the dikes, and in hand specimens the rock presents a rather pronounced greenish hue, resulting from the alteration. The second type is more or less completely thinly schistose, and is largely composed of hornblende, some feldspar and quartz, and may contain much additional pyrite. The rock is a typical amphibolite derived from an original diabase or diorite or both.

The structural relations of the dikes to each other and to the inclosing granites clearly indicate at least two different periods of penetration of the granites by the basic rocks, and therefore different ages for the dikes. More or less complete evidence of schistose structure in the inclosing granites is sometimes noted in those cases where cut by dikes of similar structure. I take it that the period of intrusion of the dike antedates that of the dynamic disturbance inducing schistosity into both dike and granite alike. In those cases where the dike rock remains massive and the inclosing granite shows evidence of schistose structure, the reasonable conclusion is that the basic dike material penetrated the granite after the period of dynamic disturbance closed.

GRANITE DIKES

True granite dikes of normal composition and usually fine texture are numerous in certain areas, but only in one or two instances have they been observed penetrating the granite masses. In the main granite belt of the Piedmont region dikes of this character are quite frequent, penetrating the surrounding rocks, and they must be regarded as apophyses from the granite massifs (Fig. 6). As a rule, they vary only a few degrees from the vertical; are irregular in outline; fine-grained in texture; composed of light to pink feldspar and quartz, with subordinate amount of mica, which may entirely fail at times; and they range from a few inches to several feet in width.

PEGMATITE AND APLITE.

Pegmatites are present in large numbers in some quarries and entirely fail in others. As a rule, they do not attain very large size, but are narrow, apparently deep-seated, and of aqueo-igneous origin. Others are limited in extent, surrounded entirely by the granite, marking in such cases true veins of segregation. Texture and composition of the two are identical. They are chracterized by the usual coarse crystallizations of feldspar and quartz, with subordinate stout, platy, black biotite. The feldspar may be pink or white, showing good cleavage development, and twinning on the Carlsbad law. Feldspar is the most abundant constituent, composed of microcline and orthoclase, with little plagioclase; quartz frequently occurring in very small amount. Muscovite has been observed occasionally; and tourmaline, garnet, and the rarer minerals sometimes associated with pegmatites, are strikingly absent.

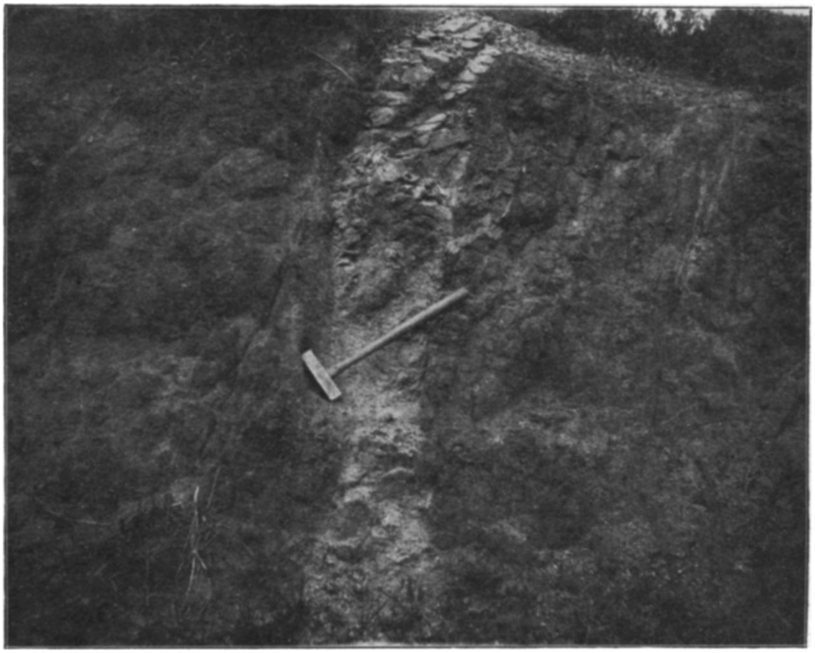

FIG. 6.—Granite dike west of Salisbury, North Carolina.

In the Raleigh city quarries where the only true aplite has been observed, the aplite and pegmatite are associated as banded aplite-pegmatite, the aplite being in contact with the pegmatite on one side and the inclosing granite on the other. They are very light-colored rocks, containing but little biotite; are fine-grained; and are only a few inches across. Orthoclase, microcline, very little plagioclase, microperthite, quartz, biotite, muscovite, chlorite, rutile, magnetite, and kaolin appear in thin section. Microscopically they are potash aplites.

QUARTZ VEINS.

Quartz veins of small dimensions cut the granite in a number of quarries; usually, in the ones where pegmatitic intrusions are strongly developed. They are not numerous in any of the openings, and, as a rule, they will not measure more than a few inches across. Veins of quartz of considerable dimensions are numerous over the crystalline area of the state, and they can be readily traced over the surface for considerable distances by partially disintegrated outcrops and abundant angular fragments which litter the surface.

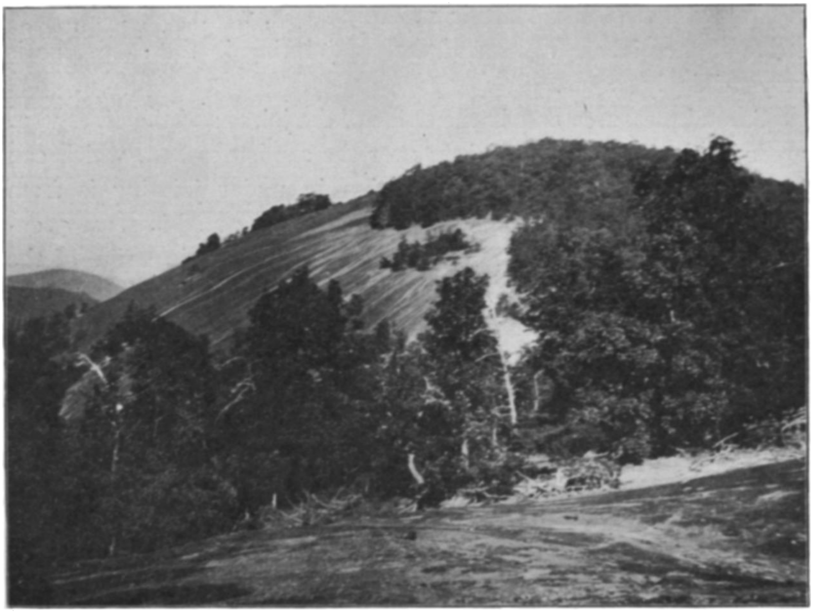

FIG. 7.—Stone Mountain, Wilkes county, North Carolina. A granite residual. Several others are shown in the distance on the extreme left of the view.

RELATIONS BETWEEN THE JOINTS IN THE GRANITE AND THE DIKES OF BASIC ROCK.

Referring to the direction in the strike of joints discussed on p. 23, it will be observed that the planes of most of the joints lie in the northeast and the northwest quadrants, respectively. Likewise careful measurement and tabulation of the dikes of basic rocks show that the direction of strike of most of them is in the same quadrants as the strike of the joints. Furthermore, in nearly every quarry exposing dikes of basic igneous rocks the strike of the dikes and that of one set of joints were coincident, probably indicating that for the areas mentioned the jointing has exercised some influence in the cutting direction of the dikes.

Not only is this true of the dikes penetrating the granites, but it is equally true of the Triassic sandstone belt, where coincidence in strike of the diabase dikes and that of jointing in the sandstone is very strikingly shown.

Careful measurements in the strike of the joints and the dikes were made in the numerous openings over the sandstone belt, which can be summarized as follows:[1] Variation in major jointing is from N.15°–60° W. to N. 20°–60° E., with minor sets noted in some openings striking N.-S. and E.-W. Likewise, variation in strike of the dikes is from N. 20°–60° W. to N. 20° E., with a few striking N.-S. In every opening the strike of the dikes and that of the joints for a given direction was found to be coincident.

Whether this will apply in general to those dikes beyond the limits of the fresh rock exposures it is not possible to say at present, as the jointing is entirely obscured by the deep residual decay covering the fresh rocks.

AGE-RELATIONS OF THE DIKES OF BASIC IGNEOUS ROCKS.

As noted above in the basic dikes penetrating the crystalline rocks, strongly contrasted structural differences in the dike rocks obtain. Many of them are entirely massive and unaltered, bearing little or no evidence of pressure-metamorphism, while a large proportion of them are completely schistose, and are otherwise mashed and closely jointed. The ferromagnesian constituent in the latter is usually partially or completely altered. Both classes of the dikes often penetrate original massive igneous rocks that are now more or less schistose in structure. These facts afford a strong and sufficient basis for regarding the basic rocks of the dikes of different periods of intrusion, and therefore, of different age. The massive dikes penetrating the more or less schistose rocks must postdate in age the period of disturbance inducing the schistose structure in the inclosing rocks. Likewise the schistose dikes were intruded at an earlier period and prior to the metamorphism of the inclosing rocks, for the field evidence indicates that the schistose structure in the dike and the inclosing rock is the result of the same forces. Until the age of the inclosing rocks is definitely determined, that of the more schistose dikes must largely remain conjectural. As stated, the dikes must antedate the period of pressure-metamorphism affecting the inclosing rocks, for both dike and inclosing rock are similarly affected.

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[1] Data kindly furnished by Mr. F. B. Laney.

The sandstones of Triassic age occupying the marginal position along the eastern border of the Piedmont region, are cut by a system of typical massive, unaltered, diabase dikes. The dikes conform, as a rule, to northeast and northwest directions, and are coincident in strike with that of the joints in the sandstones for these directions. Nowhere have the dikes been observed to cut rocks younger than the sandstone, and their age is accordingly definitely fixed as middle Mesozoic. They are correlated with flows of the same composition and age in New Jersey, New York, and the Connecticut Valley region, and with similar dikes in Virginia and Georgia to the north and south of the Carolina area.

The dikes of the Carolina sandstone belt are traced into the neighboring crystalline rocks of the Plateau region, where they have wide distribution. Beyond the limits of the sandstone belt, in the crystalline areas penetrated by the dikes, close similarity in texture, structure, and composition of the massive dikes obtains, and their relations to the inclosing crystalline rocks make it reasonably certain that they are of the same age as those penetrating the Triassic sandstones.

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